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Goldray Carbonatite Complex

District of Cochrane

Ontario Geological Survey
Study 40

by R. P. Sage

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Foreword

The Goldray Carbonatite Complex was examined as part of a project to study alkalic rock – carbonatite complexes in Ontario. The study describes the rock types and mineralogy of the complex and outlines the history of the mineral exploration efforts within the complex.

V.G. Milne

Director
Ontario Geological Survey

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Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

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1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

***Note:** Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in cooperation with the Coal Association of Canada.*

Geology of
Carbonatite – Alkalic Rock Complexes in Ontario:
Goldray Carbonatite Complex
District of Cochrane

R.P. Sage[1]

1. Geologist, Precambrian Geology Section, Ontario Geological Survey, Toronto. Manuscript approved for publication by John Wood, Chief Geologist, Ontario Geological Survey, June 1983.

This report is published with the permission of V.G. Milne, Director, Ontario Geological Survey.

Abstract

The Goldray Carbonatite Complex occurs in the northern portion of the Kapuskasing Subprovince of the Superior Province. The complex was likely emplaced into a north–trending fault zone and has been subjected to deformation and recrystallization. The carbonatite consists of sovite, silicocarbonatite, hornblendite and fenitized plagioclase gneisses. A uranium–lead zircon isotopic age of 1884 ± 2 Ma has been obtained from the complex. The Goldray Carbonatite Complex was discovered during exploration of the region by Argor Explorations Limited in 1966. Subsequent testing of the carbonatite failed to disclose economic concentrations of minerals of interest. The carbonatite–hornblendite contact area warrants checking for the occurrence of vermiculite and the weathered surface should be examined for possible residual deposits.

Résumé

Le complexe de carbonatite Goldray est situé dans la partie nord de la sous–province de Kapuskasing, dans la province Supérieure. Son emplacement résulte probablement d'une zone de faille orientée vers le nord et le complexe a été soumis à la déformation et à la recristallisation. La carbonatite est formée de sovite, de silicocarbonatite, de hornblendite et de gneiss plagioclases fénitisés. D'après les techniques isotopiques de datation à l'uranium–zircon–plomb, l'âge du complexe est de 1884 ± 2 Ma. Le complexe de carbonatite Goldray a été découvert en 1966 lors de la prospection effectuée par Argor Explorations Limited. L'analyse de la carbonatite effectuée par la suite n'a pas permis de déceler de minerais à valeur commerciale. En raison de la zone de contact de la carbonatite et de l'hornblendite, on devrait vérifier la présence de vermiculite et la surface désagrégée devrait être examinée afin de déterminer si elle renferme des gisements résiduels.

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Introduction

The Goldray Carbonatite Complex occurs at the north end of the Kapuskasing Subprovince of the Superior Province and was likely emplaced into one of the numerous fault zones of the Kapuskasing Subprovince. The carbonatite was discovered in 1966 by diamond drilling by Argor Explorations Limited. The carbonatite consists of sovite, silicocarbonatite and hornblendite and has been isotopically dated as Middle Precambrian. As part of the alkalic rock — carbonatite study undertaken by the Ontario Geological Survey, a petrographic examination was done on a limited number of core samples obtained from the 1966 drilling.

Acknowledgment

The author was given permission to sample the Argor core by Mr. Arthur Stollery of Morrison Petroleum Limited; formerly Consolidated Morrison Mines Limited. Mr. A. Michel assisted the author in making the coreshed habitable, and Mr. L. Luhta, Resident Geologist, Timmins, assisted the author in the sampling process. In 1988, Mr. A. Lisowyk revised the statistical compositions in Appendix A.

Location and Access

Access to the complex is by helicopter. The complex is located at approximately 50°25'N latitude and 81°04'W longitude. The location of the carbonatite is illustrated in Figure 1.

Physiography

The area is covered by marshy ground and topography is relatively flat.

Laboratory Technique

The sampling was restricted to relatively homogeneous sections of core of sufficient size to obtain a thin section and material for chemical analysis.

Previous Work

No detailed study has been completed on the Goldray Carbonatite Complex. Brief mention of the complex was made by Bennett *et al.* (1967) and Gittins *et al.* (1967) determined a K–Ar isotopic age for the complex. S.T. Kwon (University of California, Santa Barbra, California, personal communication, 1987) determined a U–Pb isotopic age for the complex.

Nomenclature

In describing the lithology of the Goldray Carbonatite Complex the author has used only two rock names to describe the carbonatite rocks: sovite and silicocarbonatite.

Sovite. A carbonatite rock composed of 50% or more calcite. Various mineralogic modifiers are used to classify the sovite, for example, apatite–magnetite sovite, olivine–amphibole sovite, etc.

Silicocarbonatite. A carbonate–rich rock containing 50% or more oxide and silicate minerals. Where the silicate or oxide minerals make up more than 90% of

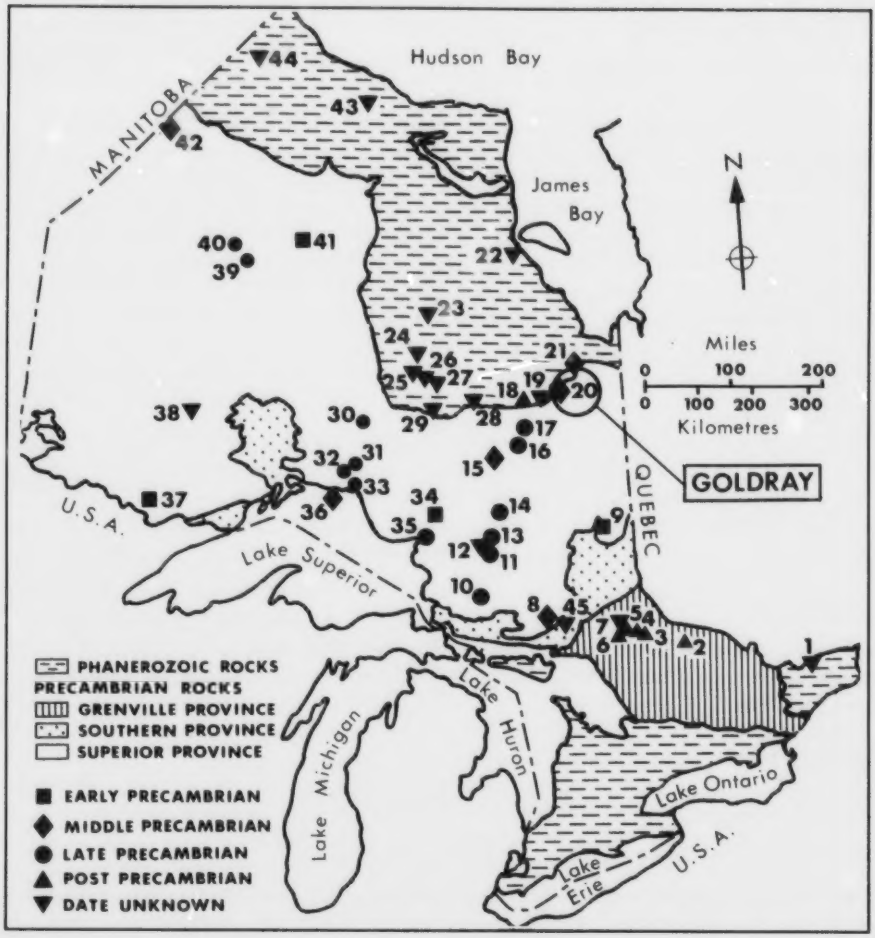

Figure 1. *Key map showing location of carbonatite - alkalic rock complexes in Ontario.*

1. *Eastview*
2. *Brent*
3. *Callander B.*
4. *Manitou Is.*
5. *Burritt Is.*
6. *Iron Is.*
7. *Lavergne*
8. *Spanish R.*
9. *Otto Stock*
10. *Seabrook L.*
11. *Lackner L.*
12. *Borden Tp.*
13. *Nemegosenda L.*
14. *Shenango Tp.*
15. *Cargill Tp.*
16. *Teetzel Tp.*
17. *Clay-Howells*
18. *Hecla-Kilmer*
19. *Valentine Tp.*
20. **Goldray**
21. *Argor*
22. *Lawashi R.*
23. *Poplar R.*
24. *Albany Forks*
25. *L. Drowning R.*
26. *Kingfisher R. West*
27. *Kingfisher R. East*
28. *Martison L.*
29. *Nagagami R.*
30. *Chipman L. (dikes)*
31. *Killala L.*
32. *Prairie L.*
33. *Port Coldwell*
34. *Herman L.*
35. *Firesand R.*
36. *Slate Is.*
37. *Pookbah L.*
38. *Sturgeon Narrows & Squaw L.*
39. *Schryburt L.*
40. *Big Beaver House*
41. *Wapikopa L.*
42. *"Carb" L.*
43. *Gooseberry Br.*
44. *Niskibi L.*
45. *Nemag L. & Lusk L.*

the rock, various other rock names are applied; i.e. ijolite, biotite, pyroxenite, etc.

The definitions of sovite and silicocarbonatite are modified from Heinrich (1966, p.12). The author has found Heinrich's subdivision of the carbonate–rich carbonatitic rocks generally suitable for field usage when modified to a two–fold subdivision at about 50% oxide and silicate mineral contents. The two–fold subdivision is more convenient than the four–fold subdivision of Heinrich (1966) because carbonatites show extreme variations in mineral content over distances of less than a few centimetres. It is difficult to rigorously classify such heterogeneous rocks.

General Geology

The intrusion has been emplaced into the northern portion of the Kapuskasing Subprovince of the Canadian Shield that is characterized by northeast–trending linear aeromagnetic anomalies, anomalous gravity highs and upper amphibolite to granulite facies rank rocks (Bennett *et al.* 1967). Due to lack of exposure little can be said concerning the geology within the immediate vicinity of the complex. Rocks associated with the carbonatite suggest that the enclosing rocks are likely to be plagioclase gneisses. The Goldray Carbonatite Complex (Figures 2, 3) is overlain by 32 to 75 m of overburden. Diamond drill hole 7–1 completed by Argor Explorations Limited indicated that the overburden consists of 2.3 m of muskeg, 67 m of fine sand, and 4.4 m of magnetic sand. Mention was made that in the drill logs for holes 7–5 and 7–6 that Paleozoic sedimentary rocks may be present, but they were not described. Reconnaissance mapping by Bennett *et al.* (1967) indicates that the complex is enclosed within granulite facies gneissic rocks of the

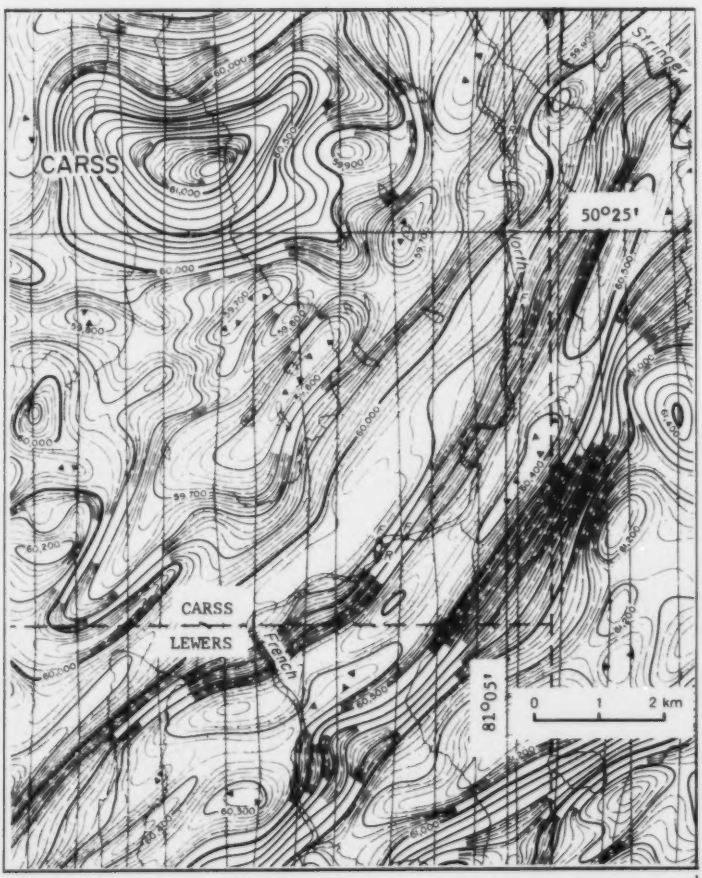

Figure 2. *Aeromagnetic map of the Goldray Carbonatite Complex (from Aeromagnetic Map 2325, ODM-GSC 1964).*

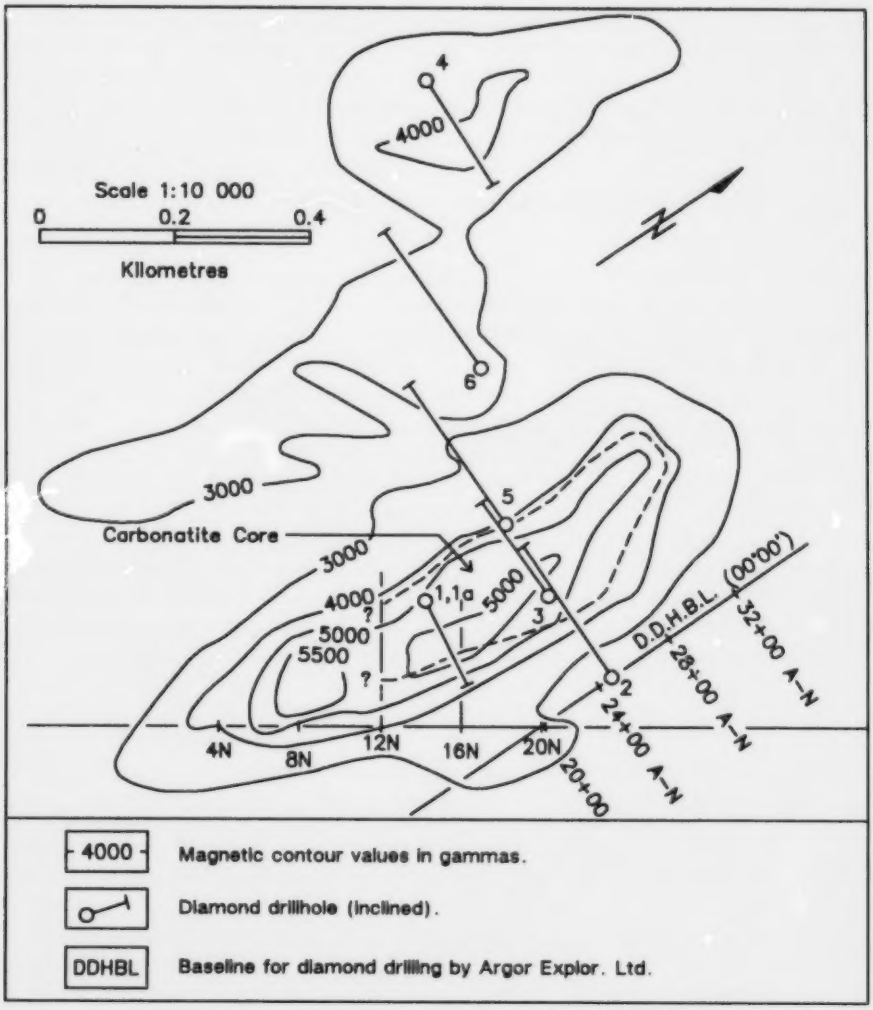

Figure 3. *Ground magnetic map of the Goldray Carbonatite Complex, showing the location of drillholes by Argor Exploration Ltd. (from file 83.1-45, Assessment Files Research Office, Ontario Geological Survey, Toronto).*

Kapuskasing Subprovince of the Superior Province. The lithologic units are given in Table 1.

MIDDLE PRECAMBRIAN
GOLDRAY CARBONATITE COMPLEX

FENITE

Fenitized gneissic wall rock was encountered in several drill holes. Two specimens from hole 7–5 were examined in thin section.

In thin section the rock is texturally massive, inequigranular–seriate, allotriomorphic, granoblastic–protoclastic, with straight to curved grain boundaries.

TABLE 1. TABLE OF LITHOLOGIC UNITS FOR THE GOLDRAY CARBONATITE COMPLEX.

CENOZOIC
QUATERNARY
Recent
Swamp and stream deposits.
Pleistocene
Sand and gravel.
Unconformity
PALEOZOIC
Sedimentary rocks (?)
Unconformity
MIDDLE PRECAMBRIAN (PROTEROZOIC)
GOLDRAY CARBONATITE COMPLEX
Carbonatite Rocks
Sovite; silicocarbonatite.
Ultramafic Rocks
Hornblendite.
Fenite
Fenitized plagioclase gneiss.
Intrusive Contact
EARLY PRECAMBRIAN (ARCHEAN)
Gneissic Rocks

The mode is estimated to be 15 to 20% amphibole, 15% biotite and 60 to 70% plagioclase. Trace to minor amounts of clinopyroxene, magnetite, carbonate and sericite are present.

Amphibole occurs as elongated stubby crystals of green to dark green colour. The mineral occurs between feldspar grains and as finer grained clots associated with plagioclase, biotite and opaques.

Biotite is present as anhedral to subhedral tabular brown grains. In one specimen it displays a preference to occur with fine-grained clots of amphibole, plagioclase and opaques.

The plagioclase (An 28–38) forms an anhedral, interlocking, mosaic of tabular grains. Bent albite twin planes and fractures filled with carbonate are present in one sample. In the second sample, the plagioclase consists of larger fractured grains with bent albite twin planes, separated by irregular clots of fine-grained granoblastic, unstressed plagioclase in association with opaques, amphibole and biotite.

Both samples display granoblastic-protoclastic textures. Metasomatism with the addition of material is implied by the higher mafic content of recrystallized clots. The green colour of the amphibole suggests it is a sodium-iron variety. The unstressed plagioclase also appears more sodic than the enclosing larger crystals. The presence of biotite suggests potassium and iron addition and the opaques suggest iron addition. The recrystallized clots reflect iron and sodium with minor potassium metasomatism typical of a fenitizing fluid.

The clinopyroxene is present in only one thin section as anhedral colourless grains and may perhaps be a metamorphic mineral formed under granulite facies conditions.

The opaque mineral is considered to be magnetite. It occurs as anhedral disseminated grains and is most common as tiny anhedral grains in the recrystallized clots.

Tentatively the wall rock is interpreted to be a fenitized plagioclase gneiss.

HORNBLENDITE

The dominant mafic rock associated with the carbonatite is petrographically a hornblendite. This rock type was mapped as pyroxenite in the drill logs completed by Argor Explorations Limited. In the core boxes it consists of a black, medium- to coarse-grained rock.

In thin section the rock is fine to medium grained, equigranular, massive, allotriomorphic, granoblastic, with straight to curved grain boundaries. The mode is estimated to be 60 to 90% amphibole, 5 to 30% biotite–phlogopite, 0 to 5% clinopyroxene, 0 to 30% carbonate, and trace to 10% opaques (magnetite). Sphene is present in several thin sections.

The amphibole is anhedral to subhedral, and forms interlocking grains. The grains are stubby and may contain small opaque grains. The amphibole is pleochroic in brown, yellow–brown, green and dark green. Some specimens display well developed granoblastic textures with the amphibole grains forming good triple junctions. The amphibole has altered to biotite. On the basis of pleochroism the amphibole is likely a sodium–iron rich variety. Allen (1972) has completed a microprobe analysis of the amphibole and pyroxene in the hornblendite (Table 2) and one chemical analysis (Table 3).

The biotite–phlogopite occurs as anhedral to subhedral tabular grains between the amphibole grains and as anhedral ragged grains internal and marginal to the amphibole. The grains internal to the amphibole form lenses and layers with the (001) cleavage parallel to the amphibole cleavage. The dark brown pleochroism of the mica suggests that the mica is closer to biotite than phlogopite in composition.

Clinopyroxene is only a minor component in this rock type. It is anhedral, colourless and has been replaced in part by amphibole.

TABLE 2. MICROPROBE ANALYSES OF SELECTED PYROXENES AND AMPHIBOLES FROM THE GOLDRAY CARBONATITE COMPLEX. (Data from Allen 1972).

	Clinopyroxene	Amphibole
SiO_2	51.89	42.28
Al_2O_3	4.21	14.24
TiO_2	0.58	2.06
FeO*	5.49	9.01
MnO	0.11	0.12
MgO	14.29	14.03
CaO	22.96	12.13
Na_2O	0.55	2.89
K_2O	0.01	0.66
Sum	100.09	97.42

* total Fe as FeO

Goldray 1532 olivine hornblende pyroxenite. Olivine has composition Fo 69.1

TABLE 3. CHEMICAL ANALYSIS, CIPW NORM AND MODAL ANALYSIS OF WHOLE-ROCK SAMPLE FROM THE GOLDRAY CARBONATITE COMPLEX. (Data from Allen 1972).

Goldray G7-3-861 biotite hornblendite					
Chemical Analysis*		**CIPW Norm**		**Modal Analysis**	
SiO_2	39.0	Or	10.62	Amph	84.6
Al_2O_3	12.5	Ab	1.26	Bio	10.0
TiO_2	2.8	Ne	13.06	Mt	2.3
Fe_2O_3	4.7	Lc	-	Cc	3.1
FeO	13.9	An	15.32		
MnO	0.24	Wo	11.01		
MgO	8.8	En	5.91		
CaO	10.4	Fs	4.73		
Na_2O	3.0	Fo	11.14		
K_2O	1.8	Fa	9.86		
P_2O_5	0.058	Cs	-		
CO_2	1.5	Mt	6.82		
H_2O+	1.6	Il	5.32		
		Cc	3.41		
		Ap	0.13		
		Rest	1.60		
Sum	100.30		100.19		100.0

*Analyst, A.G. Loomis.

Carbonate is present in a number of samples and is anhedral and interstitial. In those samples of higher carbonate content the carbonate occurs as a mosaic of anhedral interlocking grains.

The opaque is likely magnetite. It occurs as anhedral disseminated grains sited between the larger amphibole grains. The mineral occurs poikilitically enclosed in amphibole and may itself enclose tiny blebs of carbonate.

On the basis of textural relations some magnetite likely formed as a breakdown product of pyroxene.

The hornblendite may have formed by reaction between the carbonatite magma and enclosing wall rocks but this is uncertain without additional drilling and thin section study. The very minor presence of clinopyroxene suggests that all the amphibole is not likely the alteration product of former pyroxene. The granoblastic texture of the hornblendite suggests that it has been metamorphosed and thus may be older than the carbonatite. The possibility must also be considered that the hornblendite is pre–carbonatite and not related to the carbonatite. If pre–carbonatite the hornblendite has been subjected to fenitizing fluids derived from the carbonatite and perhaps some recrystallization at the time of carbonatite emplacement. The presence at the north end of the Kapuskasing Subprovince of three carbonatites enclosed by pyroxenite suggests a genetic relationship between carbonatite and pyroxenite or its metamorphic equivalent. Perhaps the pyroxenite is altered and metamorphosed as a result of the later emplacement of the volatile–rich, lower–temperature carbonatite magma.

SILICOCARBONATITE

This rock type contains 50% or more of oxide and silicate minerals. The rocks of this group likely formed as cumulate phases, hybrid or mixed rocks, or reaction products between carbonatite magma and hornblendite.

In thin section the rock is texturally fine or medium grained, massive, equigranular to inequigranular–seriate, allotriomorphic, with straight to lobate grain boundaries. The mode is estimated to be 20 to 70% biotite–phlogopite, 0 to 15% opaques, 40 to 50% carbonate and 0 to 40% amphibole. Minor amounts of clinopyroxene, apatite, plagioclase and sphene were noted in one or more thin sections.

The biotite–phlogopite forms anhedral tabular grains that are pleochroic in light brown to brown. The (001) cleavage is often bent and kink banding of the grains is common. The mica occasionally contains an opaque grain of magnetite. One specimen disclosed mica grains with colour mottling, suggesting that compositional variation may locally exist in some mica grains. The composition of the biotite–phlogopite is likely closer to biotite than phlogopite.

The opaques are anhedral and disseminated. The opaque is considered to be magnetite and is commonly closely associated with biotite–phlogopite.

The carbonate forms a mosaic of interlocking anhedral grains. In low concentrations it is interstitial to the other minerals. In some samples the carbonate appears to be an intergrowth of two carbonates, one clear and one slightly cloudy. The intergrowths have a crude eutectic–like pattern.

The amphibole forms anhedral to subhedral green to dark green crystals. The mineral commonly encloses inclusions of biotite, and blebs of carbonate. The biotite inclusions are anhedral, ragged, and form layers or lenses within the amphibole crystals with the (001) cleavage of biotite parallel to the amphibole cleavage. The amphibole is likely a sodium–iron variety.

Clinopyroxene is uncommon and consists of anhedral green grains. It is likely a sodium–iron variety. The clinopyroxene has altered to amphibole which in turn has altered to biotite–phlogopite. The pyroxene rarely encloses opaques and tiny blebs of carbonate.

The plagioclase (An 6–8) is interstitial to and is generally finer grained than the other minerals. The mineral has a granoblastic texture and appears recrystallized. Weak bending of some albite twin planes has occurred but the mineral is commonly unstressed relative to the fenitized gneissic rocks. The plagioclase is sodic and likely represents altered, metasomatized and recrystallized wall rock fragments.

SOVITE

Rocks of this group contain 50% or more carbonate. The rocks in thin section are fine grained, massive, equigranular, allotriomorphc, with curved to straight grain boundaries. The mode is estimated to be 50 to 100% carbonate, trace to 2% biotite–phlogopite, 0 to 25% olivine, 5 to 10% opaques and 0 to 25% amphibole. Trace to minor amounts of apatite and sphene are present in one or more thin sections. Table 4 gives microprobe analyses of the dominant minerals found in the carbonate rocks.

The carbonate occurs as an interlocking mosaic of anhedral grains. The carbonate commonly appears to actually consist of a eutectic–like intergrowth of two carbonates. One carbonate is clear and the other slightly turbid. Rarely, bending

of the rhombohedral carbonate twin planes was observed. One sample appears to have been crushed and recrystallized.

The biotite–phlogopite occurs as tabular anhedral to subhedral grains. Commonly the larger grains display bent (001) cleavage, and kink banding of the mica is common in some samples. The light brown to brown pleochroism of the mica suggests that it may be closer to biotite than phlogopite in composition.

The olivine occurs as anhedral rounded grains. It is often altered to serpentine and red iddingsite along curved fractures and grain boundaries. On occasion, the complete grain may be altered. Olivine appears closely associated with the opaques. Several specimens display very narrow rims of possible secondary olivine which may be a late–stage adcumulus overgrowth. Olivine was observed to enclose tiny carbonate, magnetite and apatite grains. See Table 4 for olivine compositions.

The opaques are considered to be magnetite. The magnetite occurs as anhedral disseminated grains. The grain boundaries are sometimes ragged and blebs of carbonate are enclosed within. One example of wormy intergrowths of magnetite in amphibole is present. One grain encloses an altered grain of olivine. The magnetite displays a preference to be associated with biotite–phlogopite.

The amphibole is anhedral to subhedral and forms stubby crystals, pleochroic from colourless to pale green. Amphibole rarely encloses blebs of carbonate. Two samples display an occasional amphibole grain with wormy intergrowth of carbonate and magnetite. See Table 4 for amphibole compositions.

PETROLOGY

The Goldray Carbonatite Complex is one of several Middle Precambrian carbonatites emplaced into the northern portion of the Kapuskasing structure. The car-

TABLE 4. MICROPROBE ANALYSES OF MINERAL GRAINS FROM CARBONATITE, GOLDRAY CARBONATITE COMPLEX, SAMPLES G7-2a AND G7-2c. (Analyses by D. Watkinson, Carleton University).

	1	2	3	4	5	6
Na_2O	0.00	0.00	0.01	5.59	1.10	5.39
FeO*	20.63	35.53	37.31	15.18	14.83	14.88
SiO_2	53.45	35.69	35.44	45.60	37.86	46.14
K_2O	0.00	0.00	0.00	0.70	8.14	0.67
MgO	24.19	27.84	26.98	12.80	16.30	13.11
MnO	0.63	0.65	0.85	0.13	0.00	0.23
Al_2O_3	0.06	0.00	0.00	7.54	12.91	7.50
CaO	0.41	0.01	0.02	6.92	0.00	7.12
Cr_2O_3	0.09	0.02	0.00	0.14	0.00	0.02
NiO	0.01	0.07	0.01	0.00	0.02	0.00
TiO_2	0.00	0.00	0.00	1.79	3.04	1.77
OH	-	-	-	1.99	3.98	2.00
Total	99.47	99.82	100.62	98.40	98.19	98.84

1. Pyroxene, average of two measurements on same pyroxene grain sample 2c.
2. Olivine, enclosed by orthopyroxene, sample 2c.
3. Olivine, enclosed in carbonate, sample 2c.
4. Amphibole; center of grain adjacent to magnetite grain; sample 2a.
5. Mica, adjacent to iron amphibole, sample 2a.
6. Amphibole, large grain associated with magnetite, sample 2a.

* Total iron given as FeO.

bonatite likely formed by a process of liquid immiscibility (Freestone and Hamilton 1980; Hamilton *et al.* 1979; Le Bas and Handley 1979) and underwent a loss of alkalies and volatiles upon emplacement (Gittins *et al.* 1975). The carbonatite is thus a residuum and the hornblendite is likely a metasomatized product of pyroxenite reacting with aqueous alkali and volatile-rich liquids. Therefore, the chemical compositions (Table A–2, Appendix A) do not define petrologic (liquid) trends. The norms (Table A–4, Appendix A) are calculated after LeBas (1973) and are given for comparative purposes. The rock unit statistics were calculated by the methods outlined by Nie *et al.* (1975). Gittins (1979) studied the carbonate composition of the Goldray carbonatite and suggested a minimum liquidus temperature of 885°C for the carbonatite magma.

A study of the nearby Argor and Cargill Carbonatite Complexes of similar age and geology indicates that olivine sovites do not contain appreciable pyrochlore (Twyman 1983). The low niobium content of the Goldray complex coupled with the presence of abundant olivine is consistent with this observation. The Goldray carbonatite is therefore a cumulate phase of a relatively unfractionated carbonatite magma (Twyman 1983).

GEOCHRONOLOGY

The Goldray carbonatite has been dated by Gittins *et al.* (1967) by K–Ar techniques at 1695 Ma. This is likely a minimum age. The complex displays petrographic evidence for deformation so some argon loss can be anticipated. S.T. Kwon (University of California, Santa Barbra, personal communication, 1987) has obtained a U–Pb age of 1884 $\pm$ 2 Ma on zircon from the complex.

METAMORPHISM

The plagioclase gneisses display interstitial carbonate, and the fine–grained, granoblastic clots of plagioclase, biotite and magnetite are indicative of iron, sodium and potassium metasomatism, and recrystallization. The gneisses display a typical protoclastic–granoblastic metamorphic texture. Regional mapping by Bennett *et al.* (1967) indicates the gneisses to be of upper amphibolite to granulite facies rank of regional metamorphism.

The carbonate–rich phases display ample evidence of deformation indicated by the bent mica cleavages and rare, bent, rhombohedral cleavage of carbonate though most carbonate twin planes appear unbent. The texture appears to have formed by cataclasis followed by recrystallization of the carbonate. The two carbonates in eutectic–like intergrowth may be a product of this recrystallization. The Goldray Carbonatite Complex appears to have been dynamothermally metamorphosed. Recrystallization of the carbonate would have had to occur at pressure and temperature conditions below that which would affect biotite–phlogopite since biotite–phlogopite retains evidence of the deformation and has not been recrystallized.

STRUCTURAL GEOLOGY

The Goldray Carbonatite Complex occurs within the northern portion of the Kapuskasing Subprovince of the Superior Province. Percival and Card (1983) have interpreted the Kapuskasing Subprovince (or structural zone) as a tilted upthrust block of Archean crust. The faulting associated with this structural zone dips northwest and strikes northeast. To the east, the high–grade rocks of the

Kapuskasing Subprovince are in fault contact with low–grade rocks; to the west, the high–grade rocks grade into low–grade rocks over a distance exceeding 100 km (Percival and Card 1983).

The Kapuskasing Subprovince is characterized by northeast–trending faults (Bennett *et al.* 1967) and the Goldray Carbonatite Complex was likely emplaced into one of these northeast–trending fault zones. The complex should therefore be expected to be elongated in a northerly direction. A poor foliation was observed in thin section, largely defined by subparallel mineral elongation. The complex is likely to be mineralogically banded and to display some internal structure. A subvertical orientation of this banding is anticipated.

The abundant evidence of deformation in the mica indicates the complex underwent post–emplacement faulting and recrystallization. The shape of the complex is elongate in a northeast direction but its present shape need not be its original shape since it has been deformed.

GEOPHYSICS

The Kapuskasing Subprovince is characterized by a northeast–trending linear aeromagnetic pattern and a zone of gravity highs (Innis 1960; ODM–GSC 1970). This anomalous zone of magnetics and gravity has been interpreted to reflect major regional faulting and the formation of a horst structure (Wilson and Brisbin 1965; Bennett *et al.* 1967). Regional aeromagnetic maps indicate a strong northeast linear trend of isomagnetic contours with a weak pattern over the Goldray Carbonatite Complex (*see* Figure 2).

Ground magnetic maps (*see* Figure 3) produced by Argor Explorations Limited indicate that a north–trending anomaly approximately 840 by 210 m is present over the Goldray Carbonatite Complex. Drilling by the company has cross–sectioned the anomaly.

RECOMMENDATION FOR FUTURE STUDY

Additional microprobe study of the mineral phases is warranted and should be undertaken to properly identify the mineral phases and develop petrologic models. Research will depend on obtaining more sample material.

Economic Geology

Carbonatites are known to contain anomalous niobium, phosphorus and rare earth elements. Vermiculite and base metals are also known to occur in carbonatite complexes. In the case of the Goldray Carbonatite Complex pyrochlore (niobium) was not observed and apatite (phosphorus) occurs in quantities generally lower than what has been observed by the author in other complexes. Relative to other Ontario carbonatites the chemical data in Appendix A indicates the complex to be lower than usual in phosphorus and niobium. The relatively low apatite content likely explains the relatively low rare earth element contents since the rare earth elements in most Ontario carbonatites occur in the apatite. Vermiculite could be present in the contact area of the carbonatite with hornblendite but high concentrations were not observed in the core examined nor was biotite–phlogopite mentioned in diamond drill logs. Base metal mineralization was not noted.

Only one drillhole log mentions the overburden encountered and this reported only a thin residuum of magnetite sand. The possibility of a residual accumulation on the surface of the carbonatite can not be discounted but existing data is not encouraging. The low apatite and niobium content of the primary carbonatite should not discourage examination of the surface for residual accumulation of economic minerals.

PROPERTY DESCRIPTIONS

ARGOR EXPLORATIONS LIMITED [1967]

An airborne geophysical survey of the region was carried out by Argor Explorations Limited over three licenses of occupation held by Argor Explorations Limited, Consolidated Morrison Explorations Limited and Goldray Mines Limited. Follow–up work identified as carbonatite an anomaly referred to as Alpha 7. Ground magnetic surveys were completed over the anomaly outlining a north–trending linear magnetic anomaly. The company tested the anomaly with 2029.2 m (6764 feet) of diamond drilling. The drilling showed the presence of a carbonatite intrusion, but failed to disclose mineralization of economic interest.

RECOMMENDATIONS FOR PROSPECTORS

The surface of the complex warrants checking for residual accumulations of economic minerals. The relatively low content of apatite, and limited niobium content in the primary carbonatite should not inhibit exploration since a residual concentrate is produced by weathering. Existing data is not encouraging for locating economic mineralization in the primary carbonatite but any future work on the body should check the primary carbonatite to be sure nothing has been overlooked. Drilling of the carbonatite should penetrate the carbonatite–hornblendite contact to determine if vermiculite accumulations may be present at the contact.

Appendix A — Petrographic Descriptions, Chemical Analyses, Normative Compositions, and Statistical Compositions of Lithologic Units of the Goldray Carbonatite Complex.

TABLE A-1. PETROGRAPHIC AND FIELD DESCRIPTIONS OF WHOLE-ROCK SAMPLES* FROM THE GOLDRAY CARBONATITE COMPLEX.

Reference No. 1460
Sample No. G1A 495-495.6'

Magnetite sovite.

Fine grained, equigranular, massive, allotriomorphic, with straight to curved grain boundaries. Magnetite forms anhedral, disseminated grains. Minor anhedral olivine is weakly altered to serpentine and closely associated with magnetite. Biotite-phlogopite forms scattered subhedral grains. Locally (001) cleavage is kinked. Traces of apatite are present. Carbonate forms a mosaic of interlocking anhedral grains.

Reference No. 1461
Sample No. G1A 590-590.9'

Magnetite, biotite-phlogopite, amphibole sovite.

Fine to medium grained, massive, allotriomorphic, with curved to lobate grain boundaries. Traces of subhedral sphene are present. Amphibole forms round subhedral grains, pleochroic from colourless to pale green. Amphibole crystals are stubby, rarely twinned, and may enclose blebs of carbonate. Biotite-phlogopite forms subhedral, tabular grains with bent and kinked (001) cleavage. Opaques are anhedral, irregular in form and enclose carbonate grains.

Reference No. 1462
Sample No. G1A 686.7-687.4'

Biotite-phlogopite, carbonate hornblendite.

Fine to medium grained, massive, equigranular, allotriomorphic, with straight to curved grain boundaries. Biotite-phlogopite forms tabular grains interlocking with amphibole. Ragged grains are internal to some amphibole. Internal grains have ragged ends, and form layers and lenses with (001) cleavage parallel to amphibole cleavage. Amphibole is anhedral to subhedral, pleochroic from colourless to green-brown. Amphibole is altering to biotite. Clinopyroxene is anhedral and occurs as individual grains, and as relicts within amphibole. Pyroxene is altering to amphibole. Carbonate forms anhedral interstitial interlocking grains. Traces of sphene and opaques are present. The rock is possibly an altered pyroxenite.

Reference No. 1463
Sample No. G1A 691.2-691.8'

Biotite-phlogopite hornblendite.

Fine to medium grained, massive, equigranular, allotriomorphic, with straight to curved grain boundaries. Biotite occurs as tabular grains interlocking with amphibole and as tabular ragged grains on amphibole grain margins. The (001) cleavage of the mica is parallel to amphibole cleavage. Amphibole forms anhedral to subhedral grains interlocking with each other. Traces of opaques occur within amphibole. Amphibole is altering to biotite-phlogopite.

Reference No. 1464
Sample No. G1A 778.4-778.9'

Hornblendite.

Fine to medium grained, massive, equigranular, allotriomorphic, with straight to curved grain boundaries. Biotite-phlogopite forms anhedral tabular grains, generally lying between amphi-

**All samples were taken from drill core of Argor Explorations Ltd. The locations of the drillholes are plotted on Figure 3. The sample number indicates the hole number and the depth in feet of the core sample.*

bole grains. Amphibole is anhedral, pleochroic [illegible] green-brown. Opaques are anhedral, disseminated and common along grain [illegible] grains.

Reference No. 1465
Sample No. G1A 790.4–791.5'

Biotite–phlogopite hornblendite.

Fine to medium grained, massive, equigranular, [illegible] curved grain boundaries. Amphibole is pleochroic [illegible] developed triple junction points. Clinopyroxene is [illegible] grains are colourless and undergoing patchy replace[illegible] disseminated and concentrated along grain boundaries. Biotite-[illegible] hedral, tabular in outline. Some biotite–phlogopite appears [illegible] plays (001) cleavage parallel to amphibole cleavage.

Reference No. 1466
Sample No. G1 627.5–628.1'

Magnetite, biotite–phlogopite hornblendite.

Fine to medium grained, massive, equigranular, allotriomorphic, [illegible] straight grain boundaries. Amphibole forms anhedral yellow-brown to [illegible]. Disseminated opaques are enclosed within and occur along grain boundaries. Biotite–phlogopite forms tabular anhedral grains between amphibole grains and ragged grains internal to amphibole cleavage. Opaques are anhedral, disseminated throughout and occur as small inclusions in amphibole. Clinopyroxene is colourless, anhedral, ragged, and undergoing extensive patchy replacement by amphibole. Carbonate is anhedral and interstitial. Traces of sphene are present.

Reference No. 1467
Sample No. G1 642.1–643.0'

Magnetite, carbonate, biotite–phlogopite hornblendite.

Fine to medium grained, massive, equigranular, allotriomorphic, with straight to curved grain boundaries. Biotite–phlogopite is anhedral, tabular, often with bent (001) cleavage. It occurs as ragged grains internal to amphibole, with (001) cleavage parallel to amphibole cleavage. Carbonate is anhedral and interstitial. Opaques are anhedral, disseminated, and occur poikilitic in amphibole and as isolated grains along grain margins; opaques may enclose carbonate blebs. Amphibole is light brown to dark green-brown and contains tiny inclusions of opaques. Clinopyroxene is colourless, anhedral and is undergoing extensive replacement by amphibole.

Reference No. 1468
Sample No. G2 340.8–341.5'

Amphibole, olivine, magnetite, biotite–phlogopite sovite.

Fine grained, massive, equigranular, allotriomorphic, with curved to straight grain boundaries. Biotite–phlogopite forms tabular grains; bent and kinked (001) cleavage is common. Opaques are anhedral, disseminated and may enclose blebs of carbonate. Olivine forms rounded grains undergoing alteration to serpentine and iddingsite. Amphibole forms rounded grains enclosing carbonate and is colourless to pale green in colour. Carbonate forms a mosaic of interlocking anhedral grains.

Reference No. 1469
Sample No. G2 776.1–777.0'

Magnetite, biotite–phlogopite sovite.

Fine to medium grained, inequigranular, seriate, allotriomorphic, with curved to lobate grain boundaries. Carbonate locally appears crushed and recrystallized. Biotite–phlogopite is anhedral to subhedral and often displays bent (001) cleavage. Opaques are anhedral and disseminated. Carbonate has lobate grain boundaries and appears to be an intergrowth of two carbonates, possibly dolomite and calcite. Carbonate is locally crushed and recrystallized. Traces of apatite are present.

Reference No. 1470
Sample No. G2 910.4–911.1'

Magnetite silicocarbonatite.

Fine to medium grained, massive, equigranular, allotriomorphic, with straight to curved grain boundaries. Magnetite is euhedral and disseminated. Biotite–phlogopite forms an interlocking mosaic of anhedral to subhedral grains. The (001) cleavage is commonly bent. Local colour mottling suggests some compositional variation. Clinopyroxene is dark green to green and en-

closes opaques and blebs of carbonate. Minor ragged biotite within the pyroxene has (001) cleavage parallel to pyroxene cleavage. Pyroxene is probably a sodic-iron variety. Carbonate is anhedral and interstitial.

Reference No. 1471
Sample No. G2 930.3-930.9'

Magnetite, amphibole, biotite-phlogopite silicocarbonatite.

Fine to medium grained, massive, equigranular, allotriomorphic, with lobate to straight grain boundaries. Amphibole forms rounded, anhedral pleochroic green grains and may enclose carbonate and biotite. Opaques are anhedral and disseminated. Biotite-phlogopite forms anhedral to subhedral tabular grains with bent and kinked (001) cleavage. Carbonate is a mosaic of interlocking anhedral crystals. Locally carbonate looks like an intergrowth of two carbonates, possibly dolomite and calcite. Carbonate has ragged grain boundaries.

Reference No. 1472
Sample No. G2 947.7-948.4'

Magnetite, biotite-phlogopite, olivine sovite.

Fine to medium grained, massive, equigranular, allotriomorphic, with curved to straight grain boundaries. Olivine forms anhedral rounded grains. A number of grains appear mantled with a narrow rim of later olivine. Olivine shows minor alteration to iddingsite and serpentine. Biotite-phlogopite is anhedral, forming tabular grains. Mica often displays considerable bending of (001) cleavage. Magnetite is anhedral, disseminated, forming ragged grains which may enclose carbonate blebs.

Reference No. 1473
Sample No. G2 1120.3-1121.1'

Magnetite, biotite-phlogopite sovite.

Fine to medium grained, equigranular, massive, allotriomorphic, with straight to lobate grain boundaries. Magnetite is anhedral, disseminated and also occurs as wormy intergrowths in amphibole. Biotite-phlogopite is anhedral with bent (001) cleavage. Amphibole is present in very minor amounts and contains wormy intergrowths of magnetite. Carbonate is anhedral and forms an interlocking mosaic of anhedral grains. Carbonate appears to be an intergrowth of two carbonates in a eutectic-like fashion, possibly dolomite and calcite.

Reference No. 1474
Sample No. G2 1150.9-1151.4'

Magnetite, biotite-phlogopite sovite.

Fine grained, massive, equigranular, allotriomorphic, with curved to straight grain boundaries. Amphibole forms rounded grains of colourless to pale green colour. Amphibole is a minor component. Olivine is a minor component and forms rounded anhedral grains altering to reddish iddingsite and possibly serpentine. Opaques are anhedral and disseminated. Biotite-phlogopite forms tabular anhedral grains, commonly with bent (001) cleavage. One unusual cluster of radiating biotite was noted. Carbonate forms a mosaic of anhedral interlocking grains.

Reference No. 1475
Sample No. G2 1171.9-1172.8'

Amphibole, magnetite, biotite-phlogopite sovite.

Fine grained, massive, equigranular, allotriomorphic, with straight to curved grain boundaries. Amphibole is anhedral, colourless to pale green and contains wormy intergrowths of carbonate and magnetite. Biotite-phlogopite forms tabular crystals with bent (001) cleavage. Opaques are anhedral, disseminated, sometimes concentrated along biotite-phlogopite grain boundaries. Carbonate is anhedral and forms an interlocking mosaic of grains. Carbonate appears to be an intergrowth of two carbonates, almost eutectic-like.

Reference No. 1476
Sample No. G2 1201.4-1202.0'

Amphibole, magnetite, biotite-phlogopite sovite.

Fine to medium grained, massive, equigranular, allotriomorphic, with curved to straight grain boundaries. Olivine is a minor component forming rounded anhedral grains altering to iddingsite and possibly serpentine. It may enclose magnetite, carbonate and apatite. Amphibole is subhedral, and colourless to pale green. Wormy intergrowths of carbonate and magnetite are present. Magnetite is anhedral, disseminated and encloses blebs of carbonate. Biotite-phlogopite is anhedral, tabular and has bent (001) cleavage. Carbonate forms an interlocking mosaic of anhedral grains. Carbonate appears locally to be an intergrowth of two phases.

Reference No. 1477
Sample No. G3 339.3-339.8'

Magnetite, olivine sovite.

Fine to medium grained, massive, equigranular, allotriomorphic, with straight to curved grain boundaries. Olivine forms anhedral rounded grains altering to serpentine and reddish iddingsite. Olivine may enclose carbonate. Opaques are anhedral, ragged, disseminated, and may enclose altered olivine. Minor biotite-phlogopite forms anhedral to subhedral tabular grains with local strong bending of (001) cleavage. Minor amphibole is colourless to pale green and forms rounded grains. Carbonate forms an interlocking mosaic of anhedral grains, and appears locally to be an intergrowth of two carbonates.

Reference No. 1478
Sample No. G3 503.9-504.5'

Biotite-phlogopite, carbonate hornblendite.

Fine to medium grained, massive, equigranular, allotriomorphic, granoblastic, with curved to straight grain boundaries. Biotite-phlogopite forms small tabular crystals between amphibole grains and small ragged grains internal to amphibole. Amphibole is pale light brown to brown, interlocking with triple junction points. Carbonate is anhedral, interstitial.

Reference No. 1479
Sample No. G3 706.2-706.8'

Plagioclase, pyroxene, amphibole, biotite-phlogopite silicocarbonatite.

Fine to medium grained, inequigranular-seriate, allotriomorphic, with curved to straight grain boundaries. Clinopyroxene is green to pale green, anhedral, ragged, and altering to green amphibole in patchy fashion. It may enclose carbonate blebs. Cleavage of amphibole is parallel to cleavage of pyroxene. Amphibole forms anhedral to subhedral grains, green to dark green in colour, which may enclose ragged grains of biotite with (001) cleavage parallel to amphibole cleavage. Amphibole and biotite-phlogopite are after pyroxene. Amphibole may enclose blebs of carbonate. Opaques are anhedral and disseminated. Carbonate forms an interlocking mosaic of anhedral grains. Apatite forms rounded anhedral grains and is very minor. Plagioclase (albite?) is present and closely associated with mica. Plagioclase grains are granoblastic. The rock is possibly a hybrid close to contact with carbonatite.

Reference No. 1480
Sample No. G3 721.4-722.1'

Plagioclase, amphibole, biotite-phlogopite silicocarbonatite (fenite?).

Fine to medium grained, massive, inequigranular, allotriomorphic, with curved to straight grain boundaries. Plagioclase (An 6-8) is anhedral, irregular, intergranular to biotite, and shows rare bending of albite twin planes. It appears to be granoblastic and recrystallized. Biotite-phlogopite forms anhedral to subhedral tabular grains with bent (001) cleavage, and is observed to enclose opaques. Amphibole is green to dark green, and may enclose ragged grains of biotite. The (001) cleavage of enclosed biotite is parallel to amphibole cleavage. It appears to partially enclose larger biotite grains.

Reference No. 1481
Sample No. G3 818.6-819.2'

Amphibole, biotite-phlogopite silicocarbonatite (altered hornblendite).

Fine to medium grained, massive, equigranular, allotriomorphic, with straight to curved grain boundaries. Amphibole is anhedral, green to dark green, and may contain ragged lens-shaped grains of biotite with blebs of carbonate. Magnetite is anhedral, disseminated. Biotite-phlogopite occurs as anhedral to subhedral, brown grains with weak bending of (001) cleavage. Carbonate is anhedral and interstitial.

Reference No. 1482
Sample No. G3 878.6-879.2'

Plagioclase, magnetite, biotite-phlogopite silicocarbonatite.

Fine to medium grained, massive, equigranular, allotriomorphic, with straight to curved grain boundaries. Plagioclase (An 6) is anhedral, interstitial to biotite-phlogopite, and displays weak bending of albite twin planes. Opaques are anhedral, disseminated and occur between biotite grains. Biotite-phlogopite forms anhedral, tabular, interlocking grains which are disseminated. The (001) cleavage is bent and kinked. Carbonate is anhedral and interstitial.

Reference No. 1483
Sample No. G5 306.1-306.7'

Amphibole silicocarbonatite.

Fine to medium grained, inequigranular-seriate, allotriomorphic, with curved to straight grain boundaries. Minor clinopyroxene forms anhedral green grains and may enclose carbonate

blebs. Amphibole forms anhedral to subhedral green grains and may enclose carbonate blebs. Plagioclase (An-8) is interstitial to biotite, pyroxene and amphibole. Generally it is granoblastic and finer grained than other minerals. Biotite-phlogopite forms anhedral, tabular grains. Sphene is a common accessory. Traces of magnetite and apatite are present. Carbonate is anhedral and interstitial.

Reference No. 1484
Sample No. G5 348.4-348.8'

Fenitized plagioclase gneiss.

Medium grained, equigranular, massive, allotriomorphic, protoclastic, with straight to curved grain boundaries. Amphibole has well developed cleavage, and is anhedral and green to dark green in colour. Biotite forms tabular, anhedral to subhedral grains. Plagioclase (An 6-8) occurs as anhedral, interlocking tabular grains with bent albite twinning and carbonate-filled fractures. Carbonate is anhedral and interstitial.

Reference No. 1485
Sample No. G5 726.3-726.9'

Fenitized plagioclase gneiss.

Fine grained, massive, inequigranular-seriate, allotriomorphic, granoblastic, with curved to straight grain boundaries. Minor, colourless, anhedral clinopyroxene is present. Amphibole forms anhedral, elongate, blocky grains of green to dark green colour. Amphibole occurs in clots with plagioclase, biotite and magnetite. Magnetite occurs as tiny, anhedral grains in association with biotite, amphibole and plagioclase. Biotite occurs as anhedral to subhedral, tabular grains. Generally it occurs in clots associated with amphibole, magnetite and plagioclase. Plagioclase (An 6-8) forms an interlocking mosaic of tabular grains, commonly with bent albite twin planes. Larger plagioclase grains are more calcic than grains in finer grained clots. Finer grained plagioclase occurs in clots associated with amphibole, biotite and magnetite. Plagioclase in clots does not appear to be stressed nor have bent twin planes.

TABLE A-2. MAJOR ELEMENT ANALYSES (WEIGHT PERCENT) OF WHOLE-ROCK SAMPLES FROM THE GOLDRAY CARBONATITE COMPLEX.

				Sovite			
Ref. No.	1460	1460*	1461	1472	1473	1474	1475
SiO_2	2.90	2.71	10.50	7.21	4.41	3.54	4.17
Al_2O_3	0.35	0.35	1.08	0.51	0.50	0.31	0.66
Fe_2O_3	1.09	0.74	3.92	6.10	0.83	2.23	1.67
FeO	4.14	4.66	5.24	9.57	4.24	5.00	4.49
MgO	6.60	6.68	4.70	13.60	6.62	6.31	6.35
CaO	42.50	43.30	37.60	25.50	39.90	41.10	39.90
Na_2O	0.26	0.03	1.08	0.01	0.35	0.35	0.40
K_2O	0.05	0.06	0.29	0.10	0.21	0.06	0.37
TiO_2	0.14	0.14	0.47	0.57	0.09	0.31	0.23
P_2O_5	0.27	0.27	0.00	0.02	0.00	0.56	0.30
S	0.14	0.12	0.31	1.02	0.07	0.19	0.26
MnO	0.32	0.33	0.30	0.37	0.36	0.25	0.21
CO_2	41.60	41.90	32.20	32.00	40.90	39.50	39.40
H_2O+	0.00	0.00	0.09	0.07	0.08	0.00	0.03
H_2O-	0.26	0.26	0.15	0.22	0.18	0.27	0.22
Total	101.20	101.50	98.30	96.90	98.70	100.00	98.70
S.G.	2.85	2.85	2.92	3.10	2.85	2.88	2.87

	Sovite				Hornblendite (Metapyroxenite)		
Ref. No.	1476	1469	1468	1477	1462	1463	1464
SiO_2	17.50	1.93	7.12	8.14	40.10	39.50	39.60
Al_2O_3	2.39	0.23	0.63	0.42	11.40	12.30	11.90
Fe_2O_3	4.42	0.70	4.78	5.50	5.10	4.90	6.10
FeO	7.90	4.08	7.49	9.15	11.00	11.50	14.60
MgO	11.60	3.53	7.31	8.07	11.20	10.20	7.87
CaO	25.40	45.80	34.70	33.40	10.80	11.10	9.97
Na_2O	0.82	0.24	0.47	0.40	2.77	2.58	2.91
K_2O	1.61	0.02	0.27	0.16	1.83	1.82	1.81
TiO_2	0.74	0.17	0.72	0.75	2.80	2.76	3.01
P_2O_5	0.48	0.07	0.00	0.00	0.00	0.00	0.00
S	0.48	0.10	0.33	0.25	0.31	0.45	0.37
MnO	0.29	0.26	0.26	0.28	0.18	0.18	0.25
CO_2	24.00	40.90	33.20	30.90	1.05	0.63	0.37
H_2O+	0.73	0.00	0.00	0.49	1.09	0.82	0.85
H_2O-	0.21	0.17	0.26	0.13	0.16	0.24	0.10
Total	98.60	98.20	97.70	98.00	99.80	99.00	99.60
S.G.	3.00	2.83	2.98	3.00	3.23	3.26	3.32

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.
* Duplicate sample

Ref. No.	Sample No.	Ref. No.	Sample No.
1460	G1A 495.0-495.6	1476	G2 1201.4-1202.0
1460*	G1A 495.0-495.6	1469	G2 776.1-777.0
1461	G1A 590.0-590.9	1468	G2 340.8-341.5
1472	G2 947.7-948.4	1477	G3 339.3-339.8
1473	G2 1120.3-1121.1	1462	G1A 686.7-687.4
1474	G2 1150.9-1151.4	1463	G1A 691.2-691.8
1475	G2 1171.9-1172.8	1464	G1A 778.4-778.9

TABLE A-2. CONTINUED.

	Hornblendite (Metapyroxenite)					Silico-carbonatite	
Ref. No.	**1465**	**1466**	**1467**	**1481†**	**1478**	**1482**	**1483**
SiO_2	41.30	38.00	39.80	35.90	39.60	26.90	30.00
Al_2O_3	11.70	11.10	10.70	11.00	5.93	8.14	6.57
Fe_2O_3	5.20	5.50	5.00	4.60	4.15	5.10	5.20
FeO	11.90	12.10	11.10	12.40	8.15	11.80	9.32
MgO	9.59	10.80	10.90	9.52	12.00	6.80	5.23
CaO	11.10	11.70	12.60	10.80	15.30	15.70	21.90
Na_2O	2.73	2.33	2.46	3.11	3.84	1.13	2.83
K_2O	1.65	1.54	1.52	2.61	0.76	5.59	1.10
TiO_2	2.72	3.33	3.03	2.51	1.12	1.49	1.23
P_2O_5	0.00	0.00	0.00	0.14	0.23	1.47	0.31
S	0.33	0.65	0.36	0.35	0.09	0.16	0.62
MnO	0.21	0.14	0.15	0.20	0.25	0.23	0.28
CO_2	0.61	1.58	1.41	4.14	7.89	11.60	14.10
H_2O+	0.59	0.37	0.42	0.45	0.23	1.03	0.52
H_2O-	0.26	0.16	0.21	0.49	0.30	0.56	0.25
Total	99.90	99.30	99.70	98.20	99.80	97.70	99.50
S.G.	3.26	3.26	3.26	3.15	3.10	3.00	3.05

	Silicocarbonatite			Fenite			
Ref. No.	**1470**	**1470***	**1471**	**1480**	**1484**	**1485**	**1479**
SiO_2	27.20	27.10	24.80	35.80	54.20	52.50	15.60
Al_2O_3	8.34	8.60	6.68	11.60	17.20	23.40	3.19
Fe_2O_3	4.40	5.00	4.20	4.00	2.21	1.86	2.81
FeO	12.00	12.00	9.90	12.90	4.08	2.58	5.41
MgO	12.10	12.40	9.78	9.55	3.72	2.57	3.00
CaO	11.30	11.30	18.60	9.15	5.35	8.53	35.40
Na_2O	1.42	1.22	1.49	2.43	6.95	5.40	1.78
K_2O	4.64	4.77	3.85	4.61	1.78	0.79	0.79
TiO_2	2.09	2.11	1.61	2.68	0.57	0.13	0.41
P_2O_5	1.93	1.88	0.00	0.00	0.39	0.00	10.30
S	0.11	0.13	0.33	0.15	0.08	0.14	0.10
MnO	0.21	0.22	0.19	0.19	0.09	0.10	0.25
CO_2	11.10	10.60	16.70	4.72	2.60	0.84	20.30
H_2O+	0.95	1.36	0.63	0.78	0.31	0.23	0.35
H_2O-	0.18	0.14	0.29	0.51	0.27	0.35	0.20
Total	98.00	98.80	99.00	99.10	99.80	99.40	99.90
S.G.	3.05	3.05	2.99	3.07	2.75	2.78	2.96

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

* Duplicate sample

† Sample 1481 is altered hornblendite

Ref. No.	Sample No.	Ref. No.	Sample No.
1465	G1A 790.9-791.5	1470	G2 910.4-911.1
1466	G1 627.5-628.1	1470*	G2 910.4-911.1
1467	G1 642.1-643.0	1471	G2 930.3-930.9
1481	G3 818.6-819.2	1480	G3 721.4-722.1
1478	G3 503.9-504.5	1484	G5 348.4-348.8
1482	G3 878.6-879.2	1485	G5 726.3-726.9
1483	G5 306.1-306.7	1479	G3 706.2-706.8

TABLE A-3. TRACE ELEMENT ANALYSES (PPM) OF WHOLE-ROCK SAMPLES FROM THE GOLDRAY CARBONATITE COMPLEX.

				Sovite			
Ref. No.	1460	1460*	1461	1472	1473	1474	1475
Ag	8		6	4	1	<1	2
Au							
As							
Ba	190	495	260	120	230	240	240
Be	<1		2	<1	<1	<1	<1
Bi							
Co	13	11	24	61	16	26	31
Cr	<5	<5	<5	14	<5	<5	<5
Cu	14	12	32	75	19	48	56
Ga	6		29	15	8	7	13
Hg							
Li	6	6	6	12	<5	<5	<5
Mn							
Mo	<3	<3	<3	<3	<3	<3	<3
Nb	<30	<30	<30	<30	<30	<30	<30
Ni	<5	<5	<5	12	<5	<5	<5
Pb	<10	<10	<10	<10	<10	<10	<10
Rb	<10		<10	<10	<10	<10	<10
Sb							
Sc	15	15	10	10	6	10	10
Sn	17		14	10	7	10	27
Sr	3500	3500	3000	1500	3500	3500	3500
Ti							
V	60	65	100	150	20	150	80
Y	15	70	15	35	40	50	45
Zn	38	32	72	97	42	48	40
Zr	<10	<10	250	35	10	10	10
La	150	150	200	<100	200	250	250
Nd	110	120	140	30	110	120	130
Ce	180	180	240	60	200	200	220
Yb	5	5	6	2	9	5	5
Ta	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%

Note: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.
* Duplicate sample

Ref. No.	Sample No.	Ref. No.	Sample No.
1460	G1A 495.0-495.6	1473	G2 1120.3-1121.1
1460*	G1A 495.0-495.6	1474	G2 1150.9-1151.4
1461	G1A 590.0-590.9	1475	G2 1171.9-1172.8
1472	G2 947.7-948.4		

TABLE A-3. CONTINUED.

	Sovite				Hornblendite (Metapyroxenite)		
Ref. No.	**1476**	**1469**	**1468**	**1477**	**1462**	**1463**	**1464**
Ag	1	2	2	1	<1	1	<1
Au							
As							
Ba	250	390	210	200	370	360	350
Be	2	<1	<1	1	2	2	3
Bi							
Co	56	12	42	52	62	67	60
Cr	<5	<5	10	7	345	131	83
Cu	96	26	140	103	103	177	95
Ga	33	5	20	15	15	16	15
Hg							
Li	18	<5	6	94	3	<3	4
Mn							
Mo	<3	<3	<3	<3	<1	<1	<1
Nb	90	<30	<30	30	<30	60	100
Ni	18	<5	108	94	101	72	39
Pb	<10	<10	<10	<10	<10	<10	<10
Rb	60	<10	<10	<10	30	20	30
Sb							
Sc	15	5	10	8	30	30	20
Sn	7	12	22	10	3	2	1
Sr	1500	4500	2500	2000	350	300	250
Ti							
V	150	60	250	300	450	500	450
Y	30	<10	80	70	45	60	10
Zn	83	32	96	118	117	104	180
Zr	150	<10	60	45	150	150	250
La	150	300	200	150	<100	<100	<100
Nd	90	130	110	120	10	10	10
Ce	160	220	200	200	20	20	20
Yb	4	9	5	4	1	1	1
Ta	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%

Note: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
1476	G2 1201.4-1202.0	1462	G1A 686.7-687.4
1469	G2 776.1-777.0	1463	G1A 691.2-691.8
1468	G2 340.8-341.5	1464	G1A 778.4-778.9
1477	G3 339.3-339.8		

TABLE A-3. CONTINUED.

	Hornblendite (Metapyroxenite)					Silico-carbonatite	
Ref. No.	1465	1466	1467	1481†	1478	1482	1483
Ag	1	<1	1	<1	<1	<1	<1
Au							
As							
Ba	380	270	320	590	140	980	450
Be	2	1	1	2	3	<1	2
Bi							
Co	61	76	62	61	40	41	36
Cr	450	62	81	13	1160	<5	104
Cu	126	220	105	112	54	17	82
Ga	15	16	15	14	8	17	9
Hg							
Li	4	3	3	6	5	10	6
Mn							
Mo	<1	<1	<1	<1	<1	<1	<1
Nb	90	40	<30	100	150	200	150
Ni	102	64	46	29	178	<5	46
Pb	<10	<10	<10	<10	<10	<10	<10
Rb	20	20	20	50	<10	340	20
Sb							
Sc	30	30	30	20	50	<5	15
Sn	1	2	1	1	7	3	3
Sr	350	250	300	450	800	1000	2000
Ti							
V	500	600	600	450	250	90	150
Y	<10	90	80	15	15	45	60
Zn	136	88	86	142	124	210	160
Zr	200	150	150	200	200	100	300
La	<100	<100	<100	<100	<100	<100	<100
Nd	10	10	20	30	50	60	100
Ce	20	<20	20	60	80	120	200
Yb	2	2	1	1	1	3	4
Ta	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%

Note: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.
† Sample 1481 is altered hornblendite

Ref. No.	Sample No.	Ref. No.	Sample No.
1465	G1A 790.9-791.5	1478	G3 503.9-504.5
1466	G1 627.5-628.1	1482	G3 878.6-879.2
1467	G1 642.1-643.0	1483	G5 306.1-306.7
1481	G3 818.6-819.2		

TABLE A-3. CONTINUED.

	Silicocarbonatite			Fenite			
Ref. No.	**1470**	**1470***	**1471**	**1480**	**1484**	**1485**	**1479**
Ag	<1	-	<1	1	<1	1	2
Au							
As							
Ba	1430	1400	980	960	670	260	290
Be	<1	43	<1	2	2	2	3
Bi							
Co	46	43	49	60	16	13	14
Cr	5	5	87	14	<5	22	<5
Cu	25	24	70	44	16	34	18
Ga	14	-	10	14	11	15	40
Hg							
Li	10	6	31	8	8	14	<5
Mn							
Mo	<1	<1	<1	<1	<1	<1	<3
Nb	150	150	150	100	80	<30	90
Ni	10	10	31	32	<5	5	<5
Pb	<10	<10	<10	<10	<10	<10	<10
Rb	150	180	130	140	70	<10	40
Sb							
Sc	8	6	15	25	<5	15	<5
Sn	4	-	2	2	<1	<1	4
Sr	350	350	1000	450	900	1000	3000
Ti							
V	100	100	200	600	30	40	80
Y	90	40	<10	15	10	<10	35
Zn	180	158	142	180	69	44	74
Zr	150	150	250	100	100	20	250
La	<100	<100	<100	<100	<100	<100	250
Nd	80	70	80	30	30	20	140
Ce	120	120	120	60	40	40	240
Yb	2	2	2	1	<1	<1	7
Ta	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%

Note: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

* Duplicate sample

Ref. No.	Sample No.	Ref. No.	Sample No.
1470	G2 910.4-911.1	1484	G5 348.4-348.8
1470*	G2 910.4-911.1	1485	G5 726.3-726.9
1471	G2 930.3-930.9	1479	G3 706.2-706.8
1480	G3 721.4-722.1		

TABLE A-4. NORMATIVE MINERALS (ALKALIC ROCKS) FOR WHOLE-ROCK SAMPLES FROM THE GOLDRAY CARBONATITE COMPLEX.

	Sovite					
Ref. No.	**1460**	**1461**	**1472**	**1473**	**1474**	**1475**
QZ	0.79	3.36	1.88	0.66	1.53	1.10
CO	0.30	0.0	0.40	0.0	0.25	0.26
OR	0.30	1.71	0.59	1.24	0.35	2.18
AB	0.0	3.94	0.0	1.40	0.0	0.0
LC	0.0	0.0	0.0	0.0	0.0	0.0
KAL	0.0	0.0	0.0	0.0	0.0	0.0
NEPH	0.0	0.0	0.0	0.0	0.0	0.0
CAR	0.0	0.0	0.0	0.0	0.0	0.0
NS	0.0	0.0	0.0	0.0	0.0	0.0
AC	0.0	0.11	0.0	0.36	0.0	0.0
TH	0.60	1.37	0.02	0.31	0.80	0.92
GEH	0.0	0.0	0.0	0.0	0.0	0.0
AKM	0.0	0.0	0.0	0.0	0.0	0.0
FE-AK	0.0	0.0	0.0	0.0	0.0	0.0
D.WO	0.0	0.0	0.0	0.0	0.0	0.0
D.EN	0.0	0.0	0.0	0.0	0.0	0.0
D.FS	0.0	0.0	0.0	0.0	0.0	0.0
FO	0.0	3.88	4.52	0.0	0.0	0.0
FA	6.49	5.39	10.22	6.09	6.03	5.61
ANDR	0.0	0.0	0.0	0.0	0.0	0.0
HM	0.0	0.0	0.0	0.0	0.0	0.0
MT	1.58	5.64	8.86	1.02	3.24	2.43
SPH	0.0	0.0	0.0	0.0	0.0	0.0
PERV	0.0	0.0	0.0	0.0	0.0	0.0
RU	0.14	0.47	0.57	0.09	0.31	0.23
AP	0.64	0.0	0.05	0.0	1.33	0.71
CC	75.15	67.05	45.42	71.15	71.97	70.44
MGS	13.75	5.14	22.92	13.80	13.15	13.23
FL	0.0	0.0	0.0	0.0	0.0	0.0
ZR	0.0	0.0	0.0	0.0	0.0	0.0
BAD	0.0	0.0	0.0	0.0	0.0	0.0
H_2O	0.26	0.23	0.29	0.26	0.27	0.25
SUM	100.00	98.29	95.74	96.38	99.23	97.36

QZ - Quartz; CO - Corundum; OR - Orthoclase; AB - Albite; LC - Leucite; KAL - Kalsilite; NEPH - Nepheline; CAR - Carnegieite; NS - Na_2SiO_3; AC - Acmite; TH - Thenardite; GEH - Gehlenite; AKM - Akermanite; FE-AK - Fe-Akermanite; D.WO - Wollastonite; D.EN - Enstatite; D.FS - Ferrosilite; FO - Forsterite; FA - Fayalite; ANDR - Andradite; HM - Hematite; MT - Magnetite; SPH - Sphene; PERV - Perovskite; RU - Rutile; AP - Apatite; CC - Calcite; MGS - Magnesite; FL - Fluorite; ZR - Zircon; BAD - Baddeleyite

Note: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

Ref. No.	Sample No.	Ref. No.	Sample No.
1460	G1A 495.0-495.6	1473	G2 1120.3-1121.1
1461	G1A 590.0-590.9	1474	G2 1150.9-1151.4
1472	G2 947.7-948.4	1475	G2 1171.9-1172.8

TABLE A-4. CONTINUED.

	Sovite				Hornblendite (Metapyroxenite)		
Ref. No.	**1476**	**1469**	**1468**	**1477**	**1462**	**1463**	**1464**
QZ	3.21	0.0	2.37	1.80	1.14	4.36	2.10
CO	0.65	0.13	0.34	0.25	0.0	0.0	0.0
OR	9.50	0.06	1.59	0.94	10.80	10.74	10.68
AB	0.0	0.23	0.0	0.0	18.35	14.46	18.55
LC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
KAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NEPH	0.0	0.12	0.0	0.0	0.0	0.0	0.0
CAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TH	1.88	0.44	1.08	0.92	1.37	1.99	1.64
GEH	0.0	0.0	0.0	0.0	15.72	20.20	17.01
AKM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FE-AK	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D.WO	0.0	0.0	0.0	0.0	2.20	0.19	1.14
D.EN	0.0	0.0	0.0	0.0	1.31	0.11	0.53
D.FS	0.0	0.0	0.0	0.0	0.77	0.07	0.60
FO	12.89	0.0	3.20	6.56	18.53	17.64	13.30
FA	8.81	5.72	7.95	9.88	12.02	13.40	16.73
ANDR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MT	6.42	1.02	6.94	7.99	7.41	7.12	8.86
SPH	0.0	0.0	0.0	0.0	6.87	6.77	7.38
PERV	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RU	0.74	0.17	0.72	0.75	0.0	0.0	0.0
AP	1.14	0.17	0.0	0.0	0.0	0.0	0.0
CC	44.17	81.50	61.88	59.56	2.39	1.43	0.61
MGS	8.71	7.36	11.39	8.95	0.0	0.0	0.0
FL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ZR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H_2O	0.94	0.17	0.26	0.62	1.25	1.06	0.95
SUM	99.04	97.09	97.72	98.21	100.13	99.54	100.08

Note: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

Ref. No.	Sample No.	Ref. No.	Sample No.
1476	G2 1201.4-1202.0	1462	G1A 686.7-687.4
1469	G2 776.1-777.0	1463	G1A 691.2-691.8
1468	G2 340.8-341.5	1464	G1A 778.4-778.9
1477	G3 339.3-339.8		

TABLE A-4. CONTINUED.

	Hornblendite (Metapyroxenite)					Silico-carbonatite	
Ref. No.	1465	1466	1467	1481†	1478	1482	1483
QZ	3.64	7.86	2.86	0.0	0.0	0.0	7.17
CO	0.0	0.0	0.0	0.0	0.0	0.74	0.0
OR	9.74	9.09	8.97	13.67	2.74	13.79	6.49
AB	17.69	9.07	14.91	15.65	21.31	0.0	13.79
LC	0.0	0.0	0.0	0.0	0.0	13.14	0.0
KAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NEPH	0.0	0.0	0.0	3.65	3.67	5.16	0.0
CAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AC	0.0	0.0	0.0	0.0	4.18	0.0	0.0
TH	1.46	2.88	1.59	1.55	0.40	0.71	2.75
GEH	17.39	20.60	16.53	11.21	0.0	0.0	7.24
AKM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FE-AK	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D.WO	2.68	0.0	3.95	0.0	8.60	0.0	0.0
D.EN	1.47	0.0	2.33	0.0	5.55	0.0	0.0
D.FS	1.11	0.0	1.42	0.0	2.46	0.0	0.0
FO	15.63	18.75	17.30	16.53	16.95	10.54	9.08
FA	13.02	13.87	11.68	14.95	8.30	13.82	10.31
ANDR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MT	7.55	7.99	7.26	6.68	3.93	7.41	7.55
SPH	6.67	4.38	7.43	2.62	2.75	0.0	1.96
PERV	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RU	0.0	1.55	0.0	1.44	0.0	1.49	0.43
AP	0.0	0.0	0.0	0.33	0.54	3.48	0.73
CC	1.39	3.59	3.20	9.41	17.93	24.54	32.04
MGS	0.0	0.0	0.0	0.0	0.0	1.52	0.0
FL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ZR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H_2O	0.85	0.53	0.63	0.94	0.53	1.52	0.77
SUM	100.27	100.16	100.08	98.65	99.84	97.93	100.32

Note: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).
† Sample 1481 is altered hornblendite

Ref. No.	Sample No.	Ref. No.	Sample No.
1465	G1A 790.9-791.5	1478	G3 503.9-504.5
1466	G1 627.5-628.1	1482	G3 878.6-879.2
1467	G1 642.1-643.0	1483	G5 306.1-306.7
1481	G3 818.6-819.2		

TABLE A-4. CONTINUED.

	Silicocarbonatite		Fenite			
Ref. No.	**1470**	**1471**	**1480**	**1484**	**1485**	**1479**
QZ	0.0	0.0	0.0	2.94	12.94	1.67
CO	1.33	1.11	0.0	2.71	7.33	0.0
OR	15.67	20.31	21.64	10.51	4.66	4.66
AB	0.0	0.38	4.78	57.45	43.37	12.00
LC	6.36	0.0	0.0	0.0	0.0	0.0
KAL	0.0	0.0	0.0	0.0	0.0	0.0
NEPH	7.58	5.07	11.71	0.0	0.0	0.0
CAR	0.0	0.0	0.0	0.0	0.0	0.0
NS	0.0	0.0	0.0	0.0	0.0	0.0
AC	0.0	0.0	0.0	0.0	0.0	1.25
TH	0.49	1.46	0.0	0.35	0.62	0.44
GEH	0.0	0.0	7.02	3.72	18.22	0.0
AKM	0.0	0.0	0.0	0.0	0.0	0.0
FE-AK	0.0	0.0	0.0	0.0	0.0	0.0
D.WO	0.0	0.0	0.0	0.0	0.0	0.0
D.EN	0.0	0.0	0.0	0.0	0.0	0.0
D.FS	0.0	0.0	0.0	0.0	0.0	0.0
FO	14.29	13.64	16.58	6.46	4.46	0.18
FA	14.53	11.64	16.03	4.51	2.62	6.52
ANDR	0.0	0.0	0.0	0.0	0.0	0.0
HM	0.0	0.0	0.0	0.0	0.0	0.0
MT	6.39	6.10	5.81	3.21	2.70	3.46
SPH	0.0	0.0	0.91	0.0	0.0	0.0
PERV	0.0	0.0	0.0	0.0	0.0	0.0
RU	2.09	1.61	2.31	0.57	0.13	0.41
AP	4.57	0.0	0.0	0.92	0.0	24.38
CC	15.62	33.17	10.72	5.91	1.91	38.94
MGS	8.07	4.01	0.0	0.0	0.0	6.04
FL	0.0	0.0	0.0	0.0	0.0	0.0
ZR	0.0	0.0	0.0	0.0	0.0	0.0
BAD	0.0	0.0	0.0	0.0	0.0	0.0
H_2O	1.13	0.92	0.0	0.58	0.58	0.55
SUM	98.12	99.43	97.52	99.84	99.54	100.49

Note: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

Ref. No.	Sample No.	Ref. No.	Sample No.
1470	G2 910.4-911.1	1484	G5 348.4-348.8
1471	G2 930.3-930.9	1485	G5 726.3-726.9
1480	G3 721.4-722.1	1479	G3 706.2-706.8

TABLE A-5. AVERAGE CHEMICAL COMPOSITIONS (WEIGHT PERCENT AND PPM) OF LITHOLOGIC UNITS FOR THE GOLDRAY CARBONATITE COMPLEX.

	Sovite (N = 11)		Hornblendite (Metapyroxenite) (N = 8)	
	Mean	Std. Deviation	Mean	Std. Deviation
SiO_2	6.38	4.55	39.22	1.62
Al_2O_3	0.68	0.61	10.75	2.02
Fe_2O_3	2.91	2.07	5.07	0.58
FeO	6.00	2.11	11.59	1.79
MgO	7.40	2.88	10.26	1.27
CaO	37.19	6.83	11.67	1.65
Na_2O	0.40	0.31	2.84	0.47
K_2O	0.29	0.45	1.69	0.51
TiO_2	0.39	0.26	2.66	0.67
P_2O_5	0.18	0.21	0.05	0.09
MnO	0.29	0.05	0.20	0.04
CO_2	36.05	5.88	2.21	2.59
S	0.30	0.27	0.36	0.16
H_2O+	0.13	0.24	0.60	0.29
H_2O-	0.21	0.05	0.24	0.12
LOI	32.99	4.43	2.30	2.57
TOTAL	99.05	1.38	99.41	0.58
S.G.	2.92	0.09	3.23	0.07
Ag	2.60	2.67	<0.50	0.93
Cr	<0.82	7.33	290.62	382.86
Cu	56.45	42.23	124.00	51.71
Li	11.64	28.39	3.12	2.70
Ni	17.91	41.97	78.87	48.22
Pb	<10.00	0.00	<10.00	0.00
Zn	63.45	30.81	122.12	31.09
Be	<0.20	1.32	2.00	0.76
Co	31.27	18.63	61.12	10.03
Mo	<3.00	0.00	<1.00	0.00
Sc	10.36	3.44	30.00	9.26
Sr	2954.55	960.59	381.25	181.14
V	125.91	85.93	475.00	110.19
Y	40.00	27.20	38.12	36.15
Ga	15.10	9.68	14.25	2.60
Nb	<13.64	38.80	60.00	64.14
Rb	<3.00	22.14	22.50	16.69
Zr	49.09	81.20	181.25	37.20
Ta	<0.10	0.00	<0.10	0.00
Sn	13.60	6.59	2.25	2.05
Ba	256.82	102.18	347.50	125.56
Yb	5.36	2.06	1.25	0.46
Ce	187.27	47.56	27.50	30.12
La	172.73	103.35	<100.00	0.00
Nd	110.00	29.66	18.75	14.58

TABLE A-5. CONTINUED.

	Silicocarbonatite (N = 5)		Fenite (N = 4)	
	Mean	Std. Deviation	Mean	Std. Deviation
SiO_2	27.20	1.85	39.53	17.98
Al_2O_3	7.67	0.96	13.85	8.59
Fe_2O_3	4.78	0.45	2.72	0.94
FeO	11.00	1.29	6.24	4.59
MgO	9.26	3.18	4.71	3.26
CaO	15.76	4.62	14.61	13.96
Na_2O	1.62	0.69	4.14	2.45
K_2O	3.99	1.73	1.99	1.81
TiO_2	1.71	0.39	0.95	1.17
P_2O_5	1.12	0.90	0.35	0.49
MnO	0.23	0.03	0.16	0.08
CO_2	12.82	2.55	7.11	8.93
S	0.27	0.21	0.12	0.03
H_2O+	0.90	0.33	0.42	0.25
H_2O-	0.28	0.17	0.33	0.13
LOI	12.98	1.65	7.27	8.57
TOTAL	98.74	0.66	99.55	0.37
S.G.	3.03	0.03	2.89	0.15
Ag	-	-	0.75	1.26
Cr	39.20	51.91	6.50	13.67
Cu	43.60	30.04	28.00	13.37
Li	12.60	10.48	6.25	8.02
Ni	18.40	20.06	6.75	17.48
Pb	<10.00	0.00	<10.00	0.00
Zn	170.00	26.12	91.75	60.28
Be	-	-	2.25	0.50
Co	43.00	4.95	25.75	22.87
Mo	<1.00	0.00	<1.50	1.00
Sc	7.80	8.23	7.50	15.00
Sr	940.00	675.83	1337.50	1133.85
V	128.00	46.58	187.50	275.85
Y	45.00	36.40	12.50	18.48
Ga	-	-	20.00	13.44
Nb	160.00	22.36	60.00	60.55
Rb	160.00	132.92	60.00	62.72
Zr	190.00	82.16	117.50	96.05
Ta	<0.10	0.00	<0.10	0.00
Sn	-	-	1.00	2.45
Ba	1048.00	398.96	545.00	333.72
Yb	2.60	0.89	1.50	3.79
Ce	136.00	35.78	95.00	97.13
La	<100.00	0.00	<12.50	175.00
Nd	78.00	14.83	55.00	56.86

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